On the Series Lines in the Arc Spectrum of Mercury.

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[Plates 2 and 3.]

I. *Introduction.*—This communication is intended to constitute the first of a series of studies which have been made by the writer during the past two years, as opportunity offered, on the distribution of series lines in the arc spectrum of mercury, as well as on the constitution of some of these lines, and on their resolution by magnetic fields.

In making these studies, one of several objects kept in view was the determination, in so far as time was available, and the facilities of the laboratory permitted, of the experimental conditions which should be adopted in order to obtain photographic records which would exhibit the greatest possible amount of detail. In the present paper a summary is given of the results obtained so far, in an effort to make as complete as possible the identification of the lines belonging to the different series in the arc spectrum of mercury.

Of the series formulæ in use, that proposed by Ritz* is the one most generally adopted. In his scheme of representation, n (the number of wave-lengths in 1 cm. in a vacuum, *i.e.* λ^{-1}) is given by

$$n = \mathrm{A} - \mathrm{N}/\{m+\alpha+\beta\,(\mathrm{A}-n)\}^2, \tag{1}$$

or, approximately, by

$$n = \mathrm{A} - \mathrm{N}/\{m+\alpha+\beta \mathrm{N} m^{-2}\}^2, \tag{2}$$

where N is a universal constant 109675·0, m is an order number, A is the limit of the series, and α and β are constants which characterise the course of the series. In referring to different series, it has become usual to adopt the abbreviation m, α, β, for $\mathrm{N}/\{m+\alpha+\beta\,(\mathrm{A}-n)\}^2$, and in what follows in the paper this practice will be adhered to.

As illustrating the use of the Ritz equations, a system of a main and a first and second subordinate series of triplets would have the following representation :—

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* Ritz, 'Phys. Zeit.,' 1908, vol. 9, p. 521.

Main Series.

$\pm n = 1{\cdot}5,\ s,\ \sigma,\ -m,\ p_1,\ \pi_1$,* shortest wave-length,
$\pm n = 1{\cdot}5,\ s,\ \sigma,\ -m,\ p_2,\ \pi_2$,
$\pm n = 1{\cdot}5,\ s,\ \sigma,\ -m,\ p_3,\ \pi_3$, greatest wave-length,
where $m = 2, 3, 4$, etc.

First Subordinate or Diffuse Series.

$\pm n = 2,\ p_1,\ \pi_1,\ -m,\ d,\ \delta$, greatest wave-length,
$\pm n = 2,\ p_2,\ \pi_2,\ -m,\ d',\ \delta'$,
$\pm n = 2,\ p_3,\ \pi_3,\ -m,\ d'',\ \delta''$, shortest wave-length,
where $m = 3, 4, 5$, etc.

Second Subordinate or Sharp Series.

$\pm n = 2,\ p_1,\ \pi_1,\ -m,\ s,\ \sigma$, greatest wave-length,
$\pm n = 2,\ p_2,\ \pi_2,\ -m,\ s,\ \sigma$,
$\pm n = 2,\ p_3,\ \pi_3,\ -m,\ s,\ \sigma$, shortest wave-length,
where $m = 2{\cdot}5, 3{\cdot}5, 4{\cdot}5$, etc.

Preliminary to proceeding with the identification of series lines in the arc spectrum of mercury, a number of photographs were taken of this spectrum with a quartz single prism spectrograph. The sources used in turn for the production of the light included (1) a fused quartz Geissler tube with mercury electrodes; (2) a quartz glass Heraeus mercury arc-lamp; (3) a fused quartz arc-lamp of special design shown in fig. 1, which permitted either end-on or lateral exposures; (4) the electrodeless discharge in the

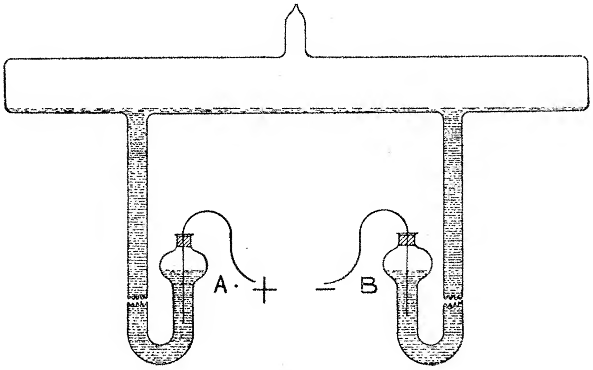

Fig. 1.

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* This frequency formula is also written in a more abbreviated form—
$n = 1{\cdot}5,\ s,\ -m,\ p.$

vapour of mercury heated in an exhausted fused quartz bulb; and (5) a commercial Cooper Hewitt glass lamp with a side tube attached, which was closed by a thin plate of crystalline quartz. Of all these sources, the last mentioned gave the best defined and the greatest number of spectral lines.

The reproduction shown in figs. 2 and 3 was made from a photograph of the spectrum taken with this lamp. The lines, some of which have become weakened in the process of reproduction, extend from slightly over $\lambda = 7000$ Å.U. down to about $\lambda = 2150$. This range is somewhat greater than that obtained by Kuch and Retschinsky* with a fused quartz glass Heraeus lamp, and by Arons† with an amalgam arc-lamp of the same type. In the spectrograms published by both of these investigators, the red end of the spectrum does not extend beyond $\lambda = 6235$, and the violet does not go below $\lambda = 2301$.

The photographic plate used in obtaining the spectrogram in figs. 2 and 3 was a Wratten and Wainwright panchromatic. (See Plates 2 and 3.)

In taking the photographs, the red lines were brought out by placing a glass plate covered with a film stained with the dye imperial scarlet before the slit of the spectrograph during an exposure of about an hour. A cell containing a solution of neodymium ammonium nitrate, and a plate covered with a film stained with the dye rhodamine pink, were then inserted for 20 minutes, to bring out the blue-greens. Afterwards, an exposure of three minutes without a screen was made, to bring out the balance of the lines. By adopting this procedure, the fogging effect due to the relatively strong intensities of the brighter lines was greatly reduced.

In figs. 4 and 5 are shown reproductions of an enlargement of portions of this spectrogram in the neighbourhood of $\lambda = 4800$ and $\lambda = 2500$. In each of these regions it will be seen there are a number of lines which evidently constitute the ends of series. These terminal lines, together with between 40 and 50 additional ones which appear in the spectrogram shown in figs. 2 and 3, seem not to have been observed by Stiles,‡ as they do not appear in a somewhat extensive list of arc lines given by him in a recent paper on the spectral lines of mercury. As a majority of these new lines was absent in the spectrograms taken by the writer with the other sources mentioned above, and as the lamp used by Stiles was somewhat different from the Cooper Hewitt lamp used in these experiments, it is clear that the character of the spectrum one obtains from the mercury arc is determined to a very considerable extent by the type of lamp used.

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* Kuch and Retschinsky, 'Ann. der Phys.,' 1907, No. 22, p. 852.

† Arons, 'Ann. der Phys.,' 1907, No. 23, p. 176.

‡ 'Astrophys. Journ.,' 1909, vol. 30, p. 48.

Previous to the appearance of a paper by Dr. S. R. Milner* on the series spectrum of mercury, but little had been done in sorting out lines of this spectrum into series. Kayser and Runge,† in their study of the arc spectrum, identified only four complete members of the triplets which constitute the first subordinate or diffuse series and the second subordinate or sharp series of this element. Arons,‡ in his paper, indicates six members of each of the groups of the first subordinate series, and seven members in the first group, and six in each of the other two groups of the sharp series, while Kuch and Retschinsky,§ in the spectrogram given by them indicate seven complete members for each of the subordinate series.

The principal series was not identified until recently, when Paschen‖ succeeded in locating the lines in the series of greatest wave-length in the infra-red region.

By far the first to do extensive work in disentangling the lines of the spectrum of mercury and sorting them into series was Milner.¶ In his paper he gave the wave-lengths of 16 lines, which, in his view, belonged to the strong group of the principal series of triplets. He also gave the wave-lengths of 16 members of the first group of the first subordinate series of triplets and the wave-lengths of 14 members of the first group of the sharp series. He showed, moreover, that a frequency formula of the Rydberg type gives a close representation of the lines constituting the principal series, viz.:—

$$\mathrm{P}_{(m)} = \mathrm{P}_{(\infty)} - \mathrm{N}/(m+0{\cdot}90845)^2, \quad \text{where} \quad \mathrm{P}_{(\infty)} = 21832{\cdot}5.$$

For the diffuse series, he found the best representation was given by a frequency formula of the type suggested by Hicks,** viz.:—

$$\mathrm{D}_{(m)} = \mathrm{D}_{(\infty)} - \mathrm{N}\Big/\left(m+0{\cdot}981485\,n - \frac{0{\cdot}178601}{m+0{\cdot}981485}\right)^2,$$

where $\mathrm{D}_{(\infty)} = 40139{\cdot}6$.

In a later paper Paschen,†† who has since made a more exhaustive study of the series lines of this spectrum, identified not only a great many lines constituting the main and the first and second subordinate series of triplets but also a number of the lines which constitute a main and a first as well as a second subordinate series of single lines. He has been able, too, to confirm the accuracy of his identification by showing that certain groups of lines in the spectrum correspond to new combination series formed from elements of the triplet system and of the system of single lines in accordance with a scheme proposed by Ritz.*

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* Milner, 'Phil. Mag.,' October, 1910, p. 636.

† Kayser and Runge, 'Ann. der Phys.,' 1891, vol. 43, p. 385.

‡ Arons, *loc. cit.*

§ Kuch and Retschinsky, *loc. cit.*

‖ Paschen, 'Ann. der Phys.,' 1909, (4), vol. 29, p. 625.

¶ Milner, 'Phil. Mag.,' October, 1910, p. 636.

** Hicks, 'Phil. Trans.,' 1910, vol. 210, p. 57.

†† Paschen, 'Ann. der Phys.,' 1911, No. 10, p. 869.

II. *Triplet System.*—According to Paschen the frequencies of the lines of the main triplet series are given approximately by the Ritz frequency formula

$$n = 2{\cdot}5,\ s,\ -m,\ p, \quad \text{where} \quad 2{\cdot}5,\ s, = 21829{\cdot}93,$$

and

$$p_1 = -0{\cdot}091568, \qquad \pi_1 = -6{\cdot}27280 \times 10^{-6},$$

$$p_2 = -0{\cdot}190016, \qquad \pi_2 = -5{\cdot}12933 \times 10^{-6},$$

$$p_3 = -0{\cdot}204153, \qquad \pi_3 = -3{\cdot}89911 \times 10^{-6}.$$

The wave-lengths of the lines of this series are given in Table I, and their distribution in the spectrum is shown in fig. 2 (Plate 2).

Table I.

Main series of triplets.	Strong $= m, p_1$.	Medium $= m, p_2$.	Weak $= m, p_3$.
$m = 2$	λ = 5460 ·944	4358 ·504	4046 ·78
3	12390 ·7	13592 ·0	—
4	6907 ·78	7082 ·27	7092 ·456
5	5803 ·77	5859 ·54	5872 ·34
6	5354 ·24	5384 ·9	5389 ·21
7	5120 ·83	5138 ·26	5140 ·27
8	4981 ·00	4991 ·7	
9	4890 ·45	4897 ·1	
10	4827 ·3	4832 ·4	
11	4782 ·3		
12	4748 ·3		
13	4723 ·0		
14	4702 ·0		
15	4685 ·5		
16	4672 ·9		
17	4662 ·29		
18	4653 ·6		

As the diagram indicates it was possible to identify 18 members of the strong group of the principal series of lines on the plate from which the figure given in this paper was made.

Lines of the medium group up to $m = 10$ could also be picked out, but none of the lines of the weak group of the principal series of triplets except that corresponding to $m = 2$ were of sufficient intensity to permit of their identification with certainty.

The lines in the first subordinate series of triplets which it has been possible to identify are given in Table II, and are shown diagrammatically in fig. 2. They are, as Milner has pointed out, closely represented by the Hicks formula*

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* Ritz, 'Phys. Zeit.,' 1908, vol. 9, p. 521; and 'Astrophys. Journ.,' 1908, vol. 28, p. 237.

$$D_{(m)} = D_{(\infty)} - N \Big/ \left(m + 0{\cdot}981485 - \frac{0{\cdot}178601}{m + 0{\cdot}981485}\right)^2,$$

where $D_{(\infty)} = 40139{\cdot}6$.

As can be seen from the diagram it has been possible to slightly extend the first group of lines of this series as given by Milner, and also to add a very considerable number of members of each of the second and third groups.

Table II.—Mercury Arc Lines of the First Subordinate or Diffuse Series.

	Group I.	Group II.	Group III.
$m = 3$	$\lambda =$ 3663·46	3131·66	2967·64
4	3027·66	2655·29	2536·72
5	2803·69	2482·14	2378·40
6	2699·75	2399·64	2301·57
7	2639·92	2352·24	2258·87
8	2603·10	2323·37	2231·86
9	2578·34	2303·62	2213·63
10	2561·15	2289·89	2200·95
11	2548·51	2279·79	2191·61
12			
13	2531·74	2266·35	2179·19
14	2525·9	2261·67	2174·87
15	2521·27	2257·96	2171·43
16	2517·57	2254·99	2168·69
17	2514·48	2252·51	
18	2512·6		
19	2510·4		
20	2508·5		

Table III contains lists of the lines belonging to the second subordinate or sharp series of triplets which it has been possible to pick out from the plates. These are also shown in fig. 2. In the first group it will be seen that the lines have been traced to $m = 20{\cdot}5$, of the second to $m = 17{\cdot}5$, and of the third to $m = 14{\cdot}5$.

The majority of these lines can be identified quite readily in the different plates excepting the higher members of the first group. These lie close to the members of the first group of the diffuse series, and while they were distinguishable on the negatives they have become somewhat obliterated in the reproductions. This identification of a number of lines in excess of those

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* Hermann, 'Ann. der Phys.,' 1905, vol. 16, p. 705. For this series Hermann gives the formula

$$n = 40136{\cdot}8 - 109675{\cdot}0 \Big/ \left(m - 0{\cdot}06923 - \frac{0{\cdot}06574}{100000}(40136{\cdot}8 - n)\right)^2.$$

noted by Milner was rendered possible, it would appear, through having obtained rather good definition in the ultra-violet below $\lambda = 2450$, and to bringing out with exceptional clearness the group of lines indicated in fig. 5 in the region between $\lambda = 2530$ and $\lambda = 2480$.

Table III.—Mercury Arc Lines of Sharp Series.

	Group I.	Group II.	Group III.
m = 2·5	λ = 5460·97	4358·56	4046·78
3·5	3341·70	2893·67	2752·91
4·5	2925·51	2576·31	2464·15
5·5	2759·83	2446·95	2345·41
6·5	2675·20	2380·22	2284·12
7·5	2625·37	2340·69	2247·69
8·5	2593·43	2312·27	2224·24
9·5	2571·85	2298·05	2208·35
10·5	2556·36	2285·68	2196·92
11·5	2545·09	2276·66	2188·59
12·5			
13·5	2529·47	2264·16	2177·03
14·5	2524·48	2260·16	2173·33
15·5	2520·5	2257·06	
16·5	2517	2254·4	
17·5	2514	2252·2	
18·5	2512		
19·5	2510		
20·5	2508		

The wave-lengths of the new lines of the different series just considered were obtained by means of a calibration scale supplied by the Adam Hilger Company with the spectrograph. All that is claimed for them, therefore, is only a fair approximation to their correct values. It will be seen, however, that they fit in fairly well with a representative formula containing the constants given by Paschen for the principal series.

III. *Single Line System.*—In addition to the main and subordinate series of triplet lines the plates in the present paper also serve to indicate the distribution of a main and two subordinate series of single lines recently discovered by Paschen.*

(a) A main series whose frequencies Paschen has calculated from the Ritz formula

$$n = 1{\cdot}5,\ \mathrm{S},\ -m,\ \mathrm{P}, \quad \text{with} \quad 1{\cdot}5,\ \mathrm{S},\ = 84176{\cdot}79,$$

consists of the lines given in Table IV.

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* Paschen, 'Ann. der Phys.,' 1909, vol. 30, p. 746; and 1911, vol. 35, p. 860.

Table IV.—Main Series of Single Lines, $n = 1{\cdot}5,\ S,\ -m,\ P$.

$m = 2$	$\lambda = 1849{\cdot}6$
3	1402·71
4	1268·9
5	1250·63
6	1232·29
7	1220·42
8	1212·71
9	1207·41
10	1203·67

These lines have not as yet been detected, and since they all lie well into the ultra-violet they are, of course, beyond the range covered in the plates accompanying this paper.

(*b*) A second main series

$$n = 2{\cdot}5,\ S,\ -m,\ P,$$

however, consists of lines which fall in part within the limits of the photographs. Their wave-lengths are given in Table V.

Table V.—Main Series of Single Lines, $n = 2{\cdot}5,\ S,\ -m,\ P$,

where $2{\cdot}5,\ S = 20252{\cdot}38$ and $m,\ P, = N/\{m+P+\mathfrak{P}(m,\ P,)\}^2$,
P being $= -0{\cdot}007597$ and $\mathfrak{P}$ being $= 3{\cdot}39281 \times 10^{-16}$.

$m = 2$	$\lambda = 10140{\cdot}6$
3	13571·9
4	6716·68
5	6234·46
6	5803·77
7	5549·5
8	5393·7
9	5290·3
10	5219·1

With the exception of the first two members these lines are shown in fig. 3 down to $m = 9$. As in the case of the main series of triplets the intensities of these lines were comparatively weak, and it was not found possible to identify them beyond the above mentioned limit. In his paper Paschen* states that his collaborator Wiedemann was able to trace the series in their plates to the member $m = 14$, which would seem to indicate that the high consumption of energy in the Arons tube (run at 20 ampères) which they used served to bring out with very exceptional clearness the lines in the red end of the spectrum.

(*c*) The wave-lengths of the different members of the first and second subordinate series of single lines, which Paschen found to be fairly well represented by the frequency formulæ

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* Paschen, 'Ann. der Phys.,' 1911, vol. 35, p. 860.

$$n = 2, \mathrm{P}, -m, \mathrm{D}, \quad \text{and} \quad n = 2, \mathrm{P}, -m, \mathrm{S},$$

are given in Tables VI and VII and their distribution is shown in fig. 3.

Table VI.—First Subordinate Series of Single Lines, $n = 2, \mathrm{P}, -m, \mathrm{D}$,

where $2, \mathrm{P}, = 30111{\cdot}10$ and $m, \mathrm{D}, = \mathrm{N}/\{m+\mathrm{D}+\mathfrak{D}(m, \mathrm{D})\}^2$,
where $3, \mathrm{D}, = 12847{\cdot}25$, $4, \mathrm{D}, = 7115{\cdot}78$, $5, \mathrm{D}, = 4520{\cdot}41$, &c.

$m = 3$	$\lambda = 5790{\cdot}87$
4	4347·62
5	3906·59
6	3704·29
7	3585
8	3518
9	3473
10	3443
11	3421
12	3403
13	3389
14	3380
15	3373
16	3366

Table VII.—Second Subordinate Series of Single Lines, $n = 2, \mathrm{P}, -m, \mathrm{S}$,

where $2, \mathrm{P}, = 30111{\cdot}10$, $m, \mathrm{S}, = 109675/\{m+\mathrm{S}+\mathfrak{S}(m, \mathrm{S})\}^2$,
and $1{\cdot}5, \mathrm{S}, = 84176{\cdot}79$, $2{\cdot}5, \mathrm{S}, = 20252{\cdot}38$, $3{\cdot}5, \mathrm{S}, = 9775{\cdot}69$, &c.

$m = 1{\cdot}5$	$\lambda = 1849{\cdot}0$
2·5	10140·48
3·5	4916·19
4·5	4108·7
5·5	3801·78
6·5	3645
7·5	3560
8·5	3500
9·5	3459
10·5	3431
11·5	3415
12·5	3396

As the tables and the diagrams show, the lines of these two series have been identified down to $m = 16$ and $m = 12{\cdot}5$ respectively, which are limits somewhat higher than those given by Paschen. In the table of lines given by Paschen for these series $m = 5{\cdot}5$ is the highest member he cites for the second subordinate series and $m = 10$ is the highest member of the first subordinate series he states that Wiedemann was able to identify in their plates.

IV. *Combination Series.*—In support of the accuracy of his identification of the different members of the triplet and single series of lines in the mercury arc spectrum, Paschen has calculated after the scheme proposed by Ritz a number of "combination series" from elements supplied by the triplet and single series formulæ, and in all the examples of these combination series which he cites there is an exceedingly close agreement between the calculated and the observed positions of these lines.

(*a*) In his first "combination series" formed from elements of the principal series of triplets and the first subordinate series of single lines the frequencies are given by

$$n = 2, p, -m, \mathrm{D},$$

where $2, p_1, = 40136{\cdot}8, \quad 2, p_2, = 44767{\cdot}29, \quad 2, p_3 = 46533{\cdot}93.$

The wave-lengths corresponding to this formula are given in Table VIII,

Table VIII.

m.	m, D.	$n = 2, p_1, -m$, D.	$n = 2, p_2, -m$, D.	$n = 2, p_3, -m$, D.
3	12847·9	λ = 3663·46	3131·95	2967·6
4	7117·4	3027·66	2655·29	2536·1
5	4521·7	2806·5	2483·9	2379·46

and by comparing them with those given in Table II it will be seen that they lie close to the lines of the diffuse series of triplets. In a number of cases they can be detected quite readily in the plates accompanying this paper. This combination series was at first supposed by Paschen to constitute the lines of the third series of satellites of the diffuse series of triplets.

(*b*) A second "combination series" which has been cited by Paschen is given by

$$n = 3, \mathrm{D}, -m, \Delta p, \quad \text{where} \quad 3, \mathrm{D}, = 12847{\cdot}9.$$

The limit of the series is approximately given by λ = 7783·36 and the members as a consequence all lie in the infra-red and, therefore, do not appear in the plates in this paper. Paschen's investigations in this region show a close agreement between the observed and calculated wave-lengths for the members $m = 4$ and $m = 5$.

(*c*) A third combination series given by him is represented by the frequency formulæ

$$n_1 = 2, \mathrm{P}, -m, d, \quad n_2 = 2, \mathrm{P}, -m, d', \quad n_3 = 2, \mathrm{P}, -m, d'',$$

where $m = 3, 4, 5$, etc., and is formed from elements of the first subordinate series of single lines, and of the diffuse series of triplets.

The wave-lengths of the lines of this series are given in Table IX.

Table IX.

m.	$n = 2, \mathrm{P}, -m, d.$	$n = 2, \mathrm{P}, -m, d'.$	$n = 2, \mathrm{P}, -m, d''.$
3	λ = 5769·81	5789·88	5790·87
4	4339·32	4343·79	4347·62
5	3902·09	3903·88	3906·59
6	3701	—	3704·29

They consist of sets of close triplets with the member of longest wave-length having the greatest intensity and the member of intermediate wave-length having the least.

By comparing these lines with those given in Table VI, it will be seen that they lie close to the lines constituting the first subordinate series of single lines. A majority of the members of this series of triplets as given in Table IX could be identified in the negatives, but, as the plates show, only two or three members can be distinguished in the reproductions.

(*d*) A fourth "combination series" given by Paschen is represented by the frequency formula

$$n = 2, \mathrm{P}, -m, s, \quad \text{where} \quad 2, \mathrm{P}, = 30111{\cdot}10$$

and $2{\cdot}5, s, = 21829{\cdot}93, \quad 3{\cdot}5, s = 10219{\cdot}73, \quad 4{\cdot}5, s, = 5963{\cdot}21.$

The first three members of this series are given in Table X.

Table X.—Combination Series $n = 2, \mathrm{P}, -m, s.$

$m = 2{\cdot}5$	$\lambda = 12071{\cdot}32$
3·5	5025·82
4·5	4140·18

As the table shows the first member of the series lies in the infra-red. The second member $\lambda = 5025{\cdot}82$ can be readily seen in the plates accompanying this paper, but the third member $\lambda = 4140{\cdot}18$ is not shown in the reproductions. This line is not given by Stiles in his list of arc lines for mercury, but one very close to it appears in his list of spark lines for this element. In the plates of the writer it is detectable as a very faint sharp line, and close to it can be seen another line of about the same intensity and sharpness. This additional line does not appear in either of the lists of arc lines given by Wiedemann or Stiles.

The positions of the second and third members of this series are shown in one of the diagrams of fig. 3.

(*e*) As representing a fifth combination series Paschen gives the relation

$$n = 2{\cdot}5, s, -m, \mathrm{P}, \quad \text{where} \quad 2{\cdot}5, s, = 21829{\cdot}93$$

and m, P, has the values given in Table XI.

Table XI.—Combination Series $n = 2{\cdot}5,\ s,\ -m,\ \mathrm{P}$.

$m = 2$	m, P = 30111·10	λ = 12071
3	12886·21	—
4	5368·11	6072·84
5	4217·13	5676·075
6	3026·92	5316·87
7	2237·68	5102·6
8	1717·28	4970·305
9	1355·1	4883·3
10	1097·3	4822·5

They have, as the frequency formula shows, a constant frequency difference of $n = 2{\cdot}5, s, -2{\cdot}5\ \mathrm{S}, = 21829{\cdot}93 - 20252{\cdot}38 = 1577{\cdot}5$ with the corresponding lines of the main series of single lines. Their distribution in the spectrum is shown in the reproduction of fig. 3, from which it will be seen that all the members have been identified up to $m = 10$. Owing to lack of intensity, however, it was impossible to trace the series beyond this limit.

(*f*) The last combination series cited by Paschen is represented by

$$n = 2, p_2, -m, \mathrm{S}, \quad \text{where} \quad 2, p_2 = 44767{\cdot}29$$

and m, S, has the values given in Table XII.

The first seven members of this series are given in Table XII.

Table XII.—Combination Series $n = 2,\ p_2,\ -m,\ \mathrm{S}$.

$m = 1{\cdot}5$	m, S = 84176·78	λ = 2536·72
2·5	20252·38	4078·05
3·5	9775·69	2857·07
4·5	5776·06	2564·14
5·5	3814·90	2441·86
6·5	2676·25	2378·4
7·5	2021·3	2340·6

The lines of this series, as can be readily seen, have a constant frequency difference with the corresponding members of the second subordinate series of single lines which is given by

$$n = 2,\ p_2,\ -2,\ \mathrm{P}, = 44767{\cdot}29 - 30111{\cdot}10 = 14656{\cdot}2.$$

The positions of the lines in the spectrum are shown in fig. 3 down to $m = 7{\cdot}5$. Beyond this limit the members of the series practically coincide with the higher members of the second group of the sharp series of triplets, and it is difficult to distinguish them in the plates.

V. *Summary of Results.*

I. By means of a modification of the Cooper Hewitt mercury arc lamp, photographs of the mercury spectrum were obtained showing well defined lines ranging from $\lambda = 2150$ to beyond $\lambda = 7000$.

II. In the triplet series of lines in the mercury arc spectrum the following members have been identified:—

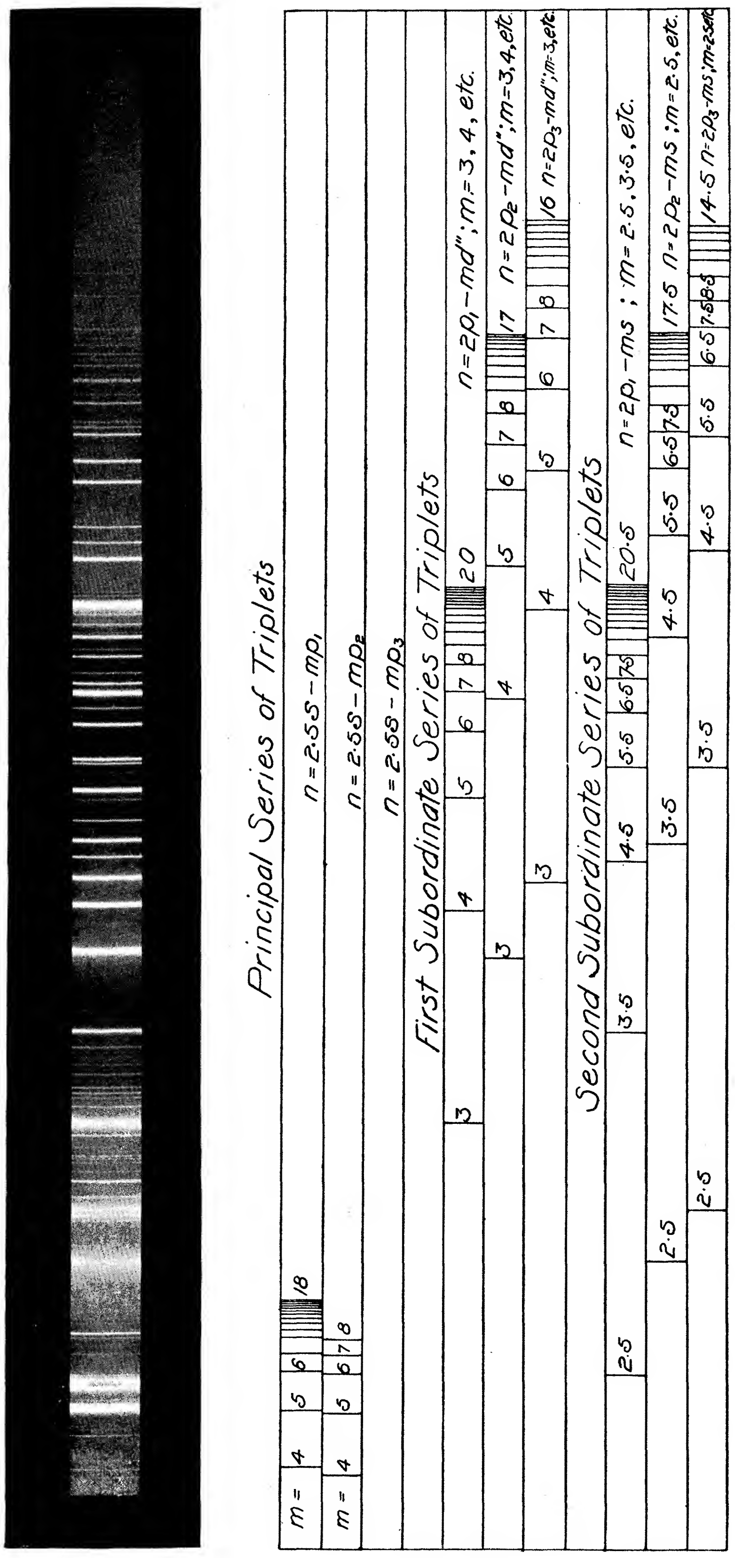
Principal series—		
	First group	to $m = 18$
	Second group	to $m = 10$
	Third group.........	—
First subordinate series—		
	First group	to $m = 20$
	Second group	to $m = 17$
	Third group.........	to $m = 16$
Second subordinate series—		
	First group	to $m = 20·5$
	Second group	to $m = 17·5$
	Third group.........	to $m = 14·5$

III. In the series of single lines in the mercury arc spectrum the following members have been identified:—

Principal series	to $m = 9$
First subordinate series	to $m = 16$
Second subordinate series	to $m = 12·5$

IV. Illustrations are given of the "combination series" lines, calculated according to the scheme proposed by Ritz from elements of the triplet series and single line series formulæ.

In conclusion, I desire to acknowledge my indebtedness to Mr. S. A. Kennedy for kindly assisting me in some preliminary work with the spectrograph used in this investigation.


Principal Series of Triplets
m = 4 5 6 18
$n = 2{\cdot}5S - mp_1$
m = 4 5 6 7 8
$n = 2{\cdot}5S - mp_2$
$n = 2{\cdot}5S - mp_3$
First Subordinate Series of Triplets
3 4 5 6 7 8 20
$n = 2p_1 - md''$; m = 3, 4, etc.
3 4 5 6 7 8 17
$n = 2p_2 - md''$; m = 3, 4, etc.
3 4 5 6 7 8 16
$n = 2p_3 - md''$; m = 3, etc.
Second Subordinate Series of Triplets
2·5 3·5 4·5 5·5 6·5 7·5 20·5
$n = 2p_1 - ms$; m = 2·5, 3·5, etc.
2·5 3·5 4·5 5·5 6·5 7·5 17·5
$n = 2p_2 - ms$; m = 2·5, etc.
2·5 3·5 4·5 5·5 6·5 7·5 8·5 14·5
$n = 2p_3 - ms$; m = 2·5 etc.

TRIPLET SERIES OF LINES OF MERCURY ARC SPECTRUM

Fig. 2

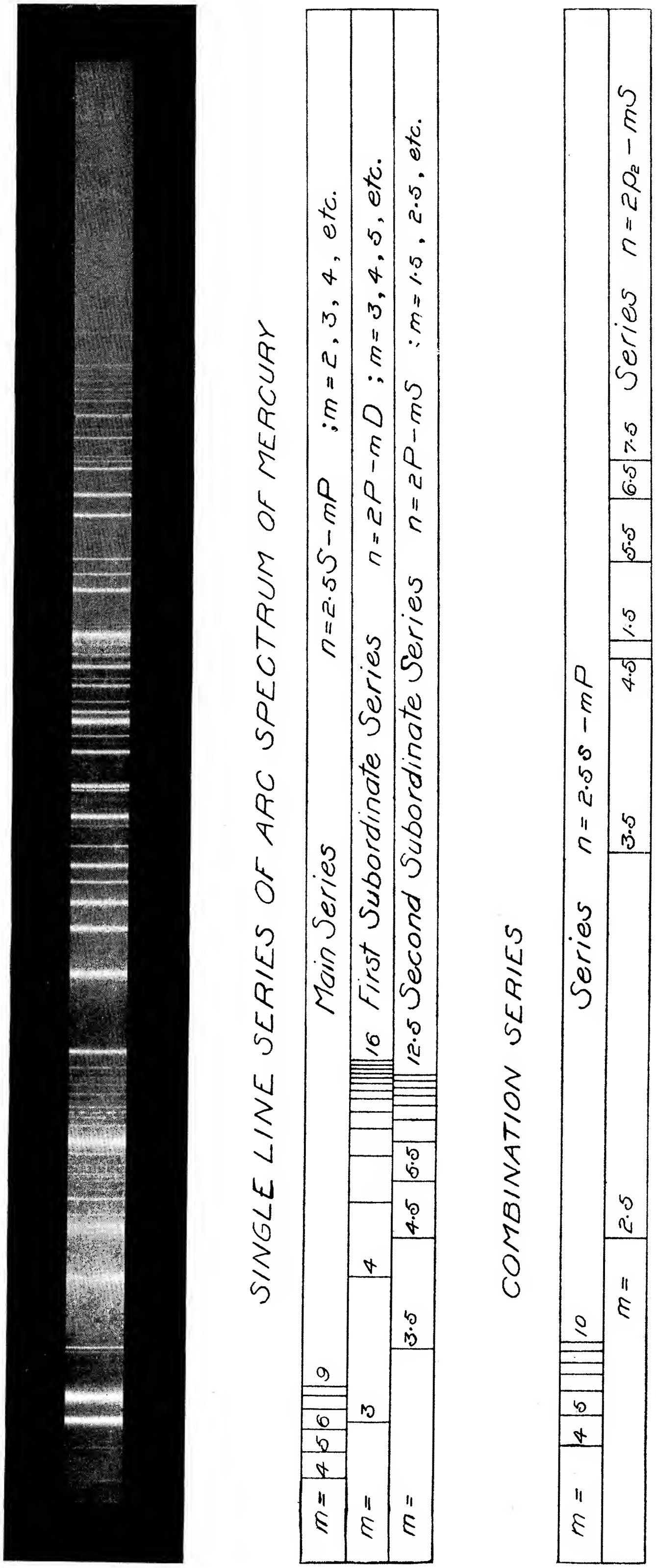

SINGLE LINE SERIES OF ARC SPECTRUM OF MERCURY
Main Series n=2·5S−mP ;m=2, 3, 4, etc.
m= 4 5 6 9
First Subordinate Series n=2P−mD ;m=3, 4, 5, etc.
m= 3 4 16
Second Subordinate Series n=2P−mS :m=1·5, 2·5, etc.
m= 3·5 4·5 5·5 12·5
COMBINATION SERIES
Series n=2·5S−mP
m= 4 5 10
Series n=2p₂−mS
m= 2·5 3·5 4·5 1·5 5·5 6·5 7·5

Fig. 3

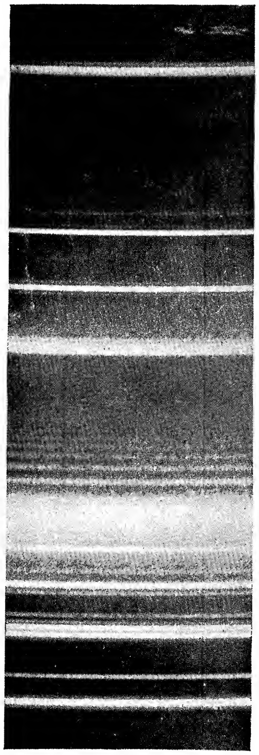


Fig. 5

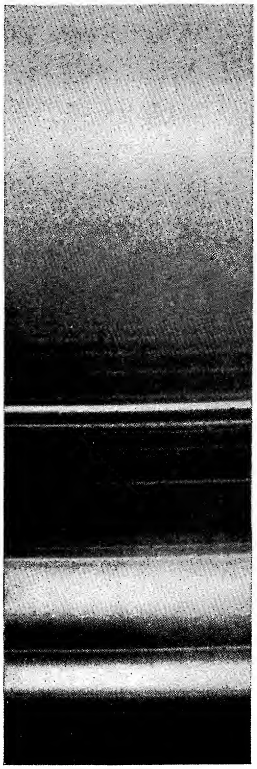
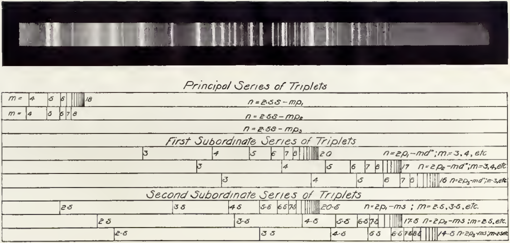


Fig. 4


Principal Series of Triplets
m = 4 5 6 18
n = 2·5S − mp₁
m = 4 5 6 7 8
n = 2·5S − mp₂
n = 2·5S − mp₃
First Subordinate Series of Triplets
3 4 5 6 7 8 20
n = 2p₁ − md″; m = 3, 4, etc
3 4 5 6 7 8 17
n = 2p₂ − md″; m = 3, 4, etc.
3 4 5 6 7 8 16
n = 2p₃ − md″; m = 3, etc.
Second Subordinate Series of Triplets
2·5 3·5 4·5 5·5 6·5 7·5 20·5
n = 2p₁ − ms ; m = 2·5, 3·5, etc.
2·5 3·5 4·5 5·5 6·5 7·5 17·5
n = 2p₂ − ms ; m = 2·5, etc.
2·5 3·5 4·5 5·5 6·5 7·5 8·5 14·5
n = 2p₃ − ms ; m = 2·5 etc.

TRIPLET SERIES OF LINES OF MERCURY ARC SPECTRUM

Fig. 2

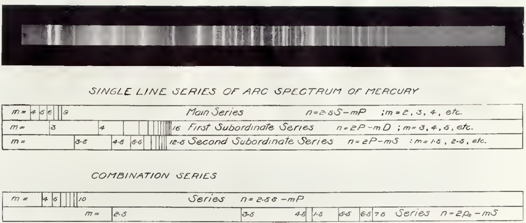

SINGLE LINE SERIES OF ARC SPECTRUM OF MERCURY
m = 4 5 6 9
Main Series n=2·5S−mP ;m = 2, 3, 4, etc.
m = 3 4 16
First Subordinate Series n=2P−mD ; m = 3, 4, 5, etc.
m = 3·5 4·5 5·5 12·5
Second Subordinate Series n=2P−mS : m=1·5, 2·5, etc.
COMBINATION SERIES
m = 4 5 10
Series n=2·5S −mP
m = 2·5 3·5 4·5 1·5 5·5 6·5 7·5
Series n=2p₂ −mS

Fig. 3

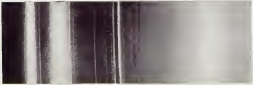


Fig. 4

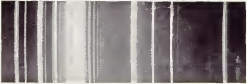


Fig. 5